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REPORT

on

WATER QUALITY

in

OTTY LAKE

1971

RECREATIONAL LAKES PROGRAM

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THE
ONTARIO WATER RESOURCES COMMISSION
REPORT

ON
WATER QUALITY
IN

OTTY LAKE

1971

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SUMMARY

A study to evaluate the status of water quality in Otty Lake was carried out during the summer of 1971.

Otty Lake is located in the Canadian Shield. Precambrian igneous and metamorphic rock form the bedrock along the north, west and south shores while Precambrian limestone is found along the east shore. Generally, there is less than the 1.5 meters (5 feet) of overburden required by the Ministry of the Environment for the installation of a standard subsurface septic tank system.

A well-defined thermocline or zone of rapid temperature decline was observed between the warm upper waters (epilimnion) and the cool bottom strata (hypolimnion) during the August and October surveys. During these periods, depressed deep-water dissolved oxygen levels and elevated carbon dioxide concentrations resulting from decomposition of organic matter were observed. Dissolved oxygen concentrations in the deeper strata were not sufficient to maintain cold-water species of fish.

Surface values for pH were usually higher than bottom-water recordings while deep-water alkalinity concentrations were generally higher than those of the upper strata.

The Kjeldahl nitrogen and total phosphorus concentrations were generally low and could not be expected to support nuisance levels of algae.

There were high concentrations of nitrogen and phosphorus in the bottom waters at two stations which could augment algal growth when the lake water becomes fully mixed in the fall.

Algal levels as measured by chlorophyll a concentrations were low during the three surveys. Such algal densities would not be expected to reduce water oriented recreational activities such as swimming and water skiing or diminish the aesthetic quality of the lake.

Otty Lake had very good bacteriological water quality and was well within the OWRC recreational use criteria during all three surveys. //

In view of the high nutrient concentrations (phosphorus and nitrogen) in the bottom waters and existing good bacteriological water quality every effort should be made to prevent any direct flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to Otty Lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw or other inadequately treated wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface

water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Otty Lake in the summer of 1971. Three surveys were conducted; a spring survey from June 11 to 15, a mid-summer survey from August 12 to 16 and a fall survey from October 23 to 26 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution control program in Ontario.

AREA DESCRIPTION

Geography and Topography

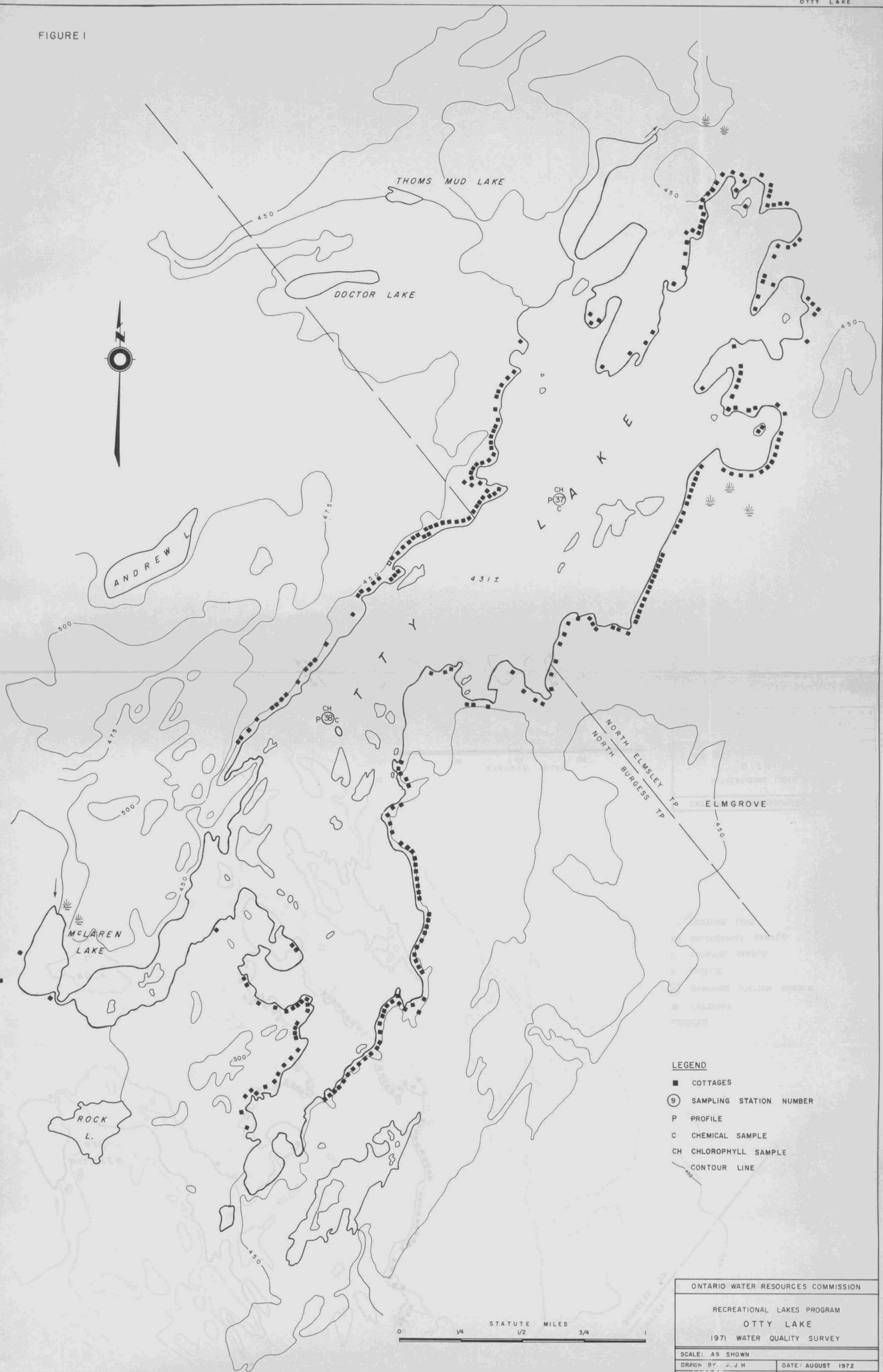
Otty Lake is located in the townships of North Burgess and North Elmsley in Lanard County. (Figure 1). The Town of Perth, on Highway No. 7, is located 5 kilometers (3 miles) northwest of the lake.

The entire body of Otty Lake lies in the Canadian Shield. Precambrian igneous and metamorphic rock form the bedrock along the north, west and south shores of the lake. The bedrock along the east shore is Precambrian limestone.

The majority of the land adjacent to the shores of Otty Lake consists mainly of a combination of soil-rock complexes. Exposed bedrock is predominant in the area although thin layers of organic materials up to 30 centimeters (12 inches) in depth occur in close association with the numerous rock outcrops. Small pockets of deep sandy loam up to a maximum of 1 meter (3 feet) are found in the irregular steep-sloping terrain. Most of the surrounding area is very stony. There are some smaller areas of muck and marsh as shown on Figure 1. The land along the shoreline near Station 36 differs slightly from the land surrounding the rest of the lake. Here the terrain is gently sloping, moderately stony and has a thin layer of sandy loam till over the limestone bedrock.

Otty Lake has a water surface area of 650 hectares (1545 acres) and a shoreline length of 35 kilometers (22 miles). The mean depth of the lake is approximately 9 meters (30 feet) with a maximum depth of 27 meters (90 feet). The limited amount of overburden supports forest vegetation and tree growth. The surround terrain is generally well-forested with birch, pine and some cedar.

FIGURE 1



- LEGEND**
- COTTAGES
 - ⑨ SAMPLING STATION NUMBER
 - P PROFILE
 - C CHEMICAL SAMPLE
 - CH CHLOROPHYLL SAMPLE
 - CONTOUR LINE

ONTARIO WATER RESOURCES COMMISSION	
RECREATIONAL LAKES PROGRAM	
OTTY LAKE	
1971 WATER QUALITY SURVEY	
SCALE: AS SHOWN	DATE: AUGUST 1972
DRAWN BY: J. J. H.	CHECKED BY: A. M.
DRAWING NO: 71-106-DE-B	

Climate Range

The mean daily temperature for the year in Lanark County is 5°C (42°F).

The mean temperatures for January, April, July and October are -10°C (14°F), 5°C (42°F), 20°C (68°F) and 8°C (47°F) respectively. The mean annual precipitation is 90 cm (34 inches) including 200 cm (80 inches) of snow. With approximately 100 days of adequate snow cover each winter the area is quite conducive to most winter sports.

Water Movement

Otty Lake is served by a watershed of 4,600 hectares (18.5 square miles) which is part of the Rideau River Basin. The land within the watershed is mainly comprised of exposed bedrock with thin layers of soil intermittently located throughout the area. Four of the six small lakes contained in the watershed are located in marsh regions which are comprised of poorly-drained organic muck.

There are four inlets to the lake, three of which have negligible flows. The creek that drains Thoms Mud Lake appears to be the only permanently flowing inlet. Jebbs Creek flows to the Tay River and is the only outlet. The private dam located on Jebbs Creek is responsible for the relatively low seasonal water level fluctuation of .5 meters (1.5 feet).

Shoreline Development

The shoreline of Otty Lake is generally well-developed with the majority of the 300 cottages located along the east and midwest shores. The cottages are generally well-spaced although some areas along the midwest shoreline appear to be crowded. The appended map shows the approximate locations of the cottages (Figure 1).

Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to information available from the Department of Lands and Forests, the most prevalent fish are northern pike, smallmouth and largemouth bass, yellow perch, rock bass, pumpkinseed and other various forage species. Otty Lake has been stocked with smallmouth bass with some regularity since 1965.

There are no direct discharges of wastes to Otty Lake from communal or municipal sewage treatment facilities. There does not appear to be any pollution from the operation of existing municipal solid waste disposal sites.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Water quality surveys were conducted on Otty Lake in June, August and October. Two near-shore stations (1 and 24) and two mid-lake stations (37 and 38) were selected for physical, chemical and/or biological sampling (Figure 1). The near-shore stations were adjacent to the major inlet and outlet.

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected at each mid-lake station in a 32-ounce bottle utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10-15 drops of 2% MgCO_3 .

Once per survey, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all stations. As well, at the major inlets and outlets, samples were collected during two of three surveys. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

At each mid-lake station one sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above the bottom on August 15, 1971.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 m μ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Otty Lake had Five-day intensive bacteriological surveys completed in June and August and a four day bacteriological survey completed in October.

Thirty-eight surface samples were taken daily as well as three depth samples at Station 9D, 17D and 21D.

Surface samples were collected at a depth of one metre below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Depth samples were collected one metre above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods, 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC), and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing microorganisms may also be present.

The coliform group is defined, according to Standard Methods, 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on the lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration may be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each stations and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

Both of these assumptions were checked on Otty Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

In June, only minor temperature differences were apparent between surface and bottom waters of the mid-lake stations (Figure 2a). The deep-water oxygen regime throughout the lake was sufficient to maintain aquatic life.

By August, a well-defined thermocline or zone of rapid temperature decline had developed between 7 and 9m (Figure 2b). This zone serves as a physical barrier to mixing between the upper warm waters (epilimnion) and the bottom cool waters (hypolimnion). Dissolved oxygen concentrations declined through the thermocline and were as low as 1.6 mg/l at 1m above bottom at Station 38 on August 13. This deep-water oxygen deficit resulted from bacterial oxidation of settled organic matter, biological respiration and chemical oxidation.

During the October survey the thermocline was located approximately 5m deeper than in the preceeding survey (Figure 3). This phenomenon as well as the cooler surface water temperatures were in keeping with the expected seasonal changes characteristic of many small inland recreational lakes. A severe dissolved oxygen decline from 9.0 (at 12m) to 0.6 mg/l (at 14m) occurred through the thermocline (Figure 3). During the period August through October dissolved oxygen concentrations in the hypolimnion were not sufficient to maintain cold-water species of fish such as lake trout, whitefish and herring and for most of the period, levels were well below the criteria established for use as domestic water supplies (i.e. 3 mg/l).

pH, Free Carbon Dioxide and Total Alkalinity

The surface pH values were higher than in the deeper strata. For example, on June 13, 1971 at Station 37, pH values were 8.5 and 7.4 at 1 and 19m respectively.

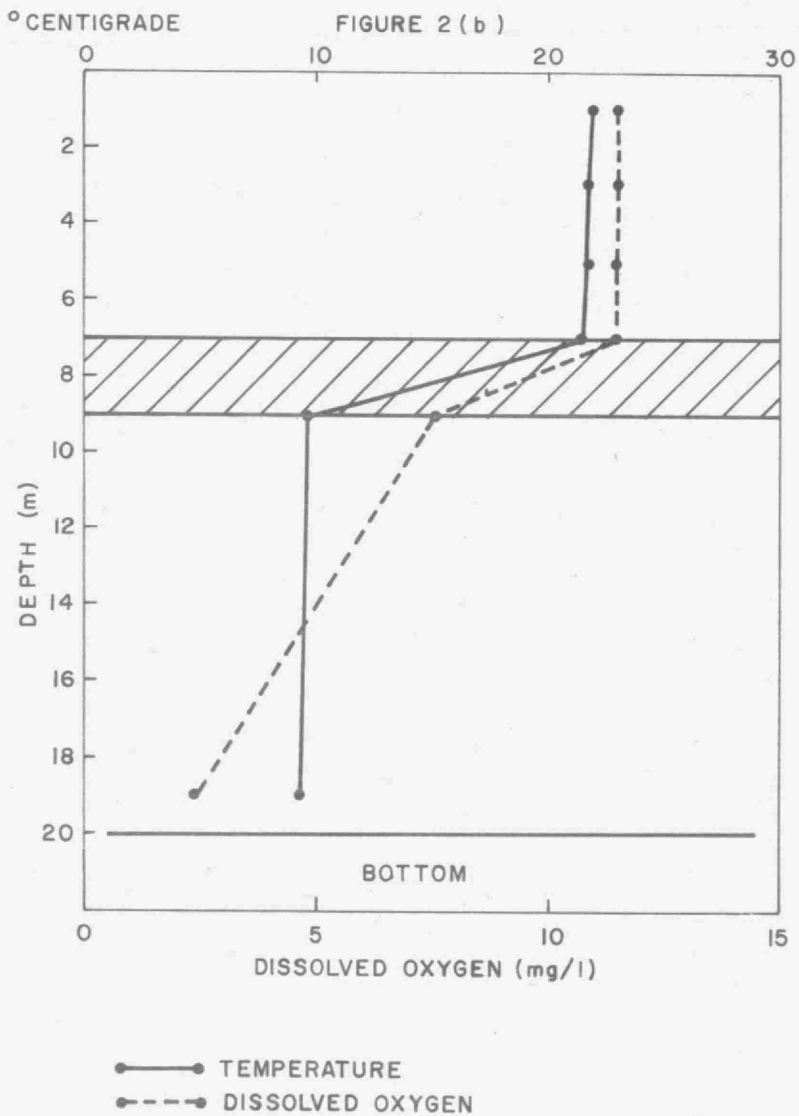
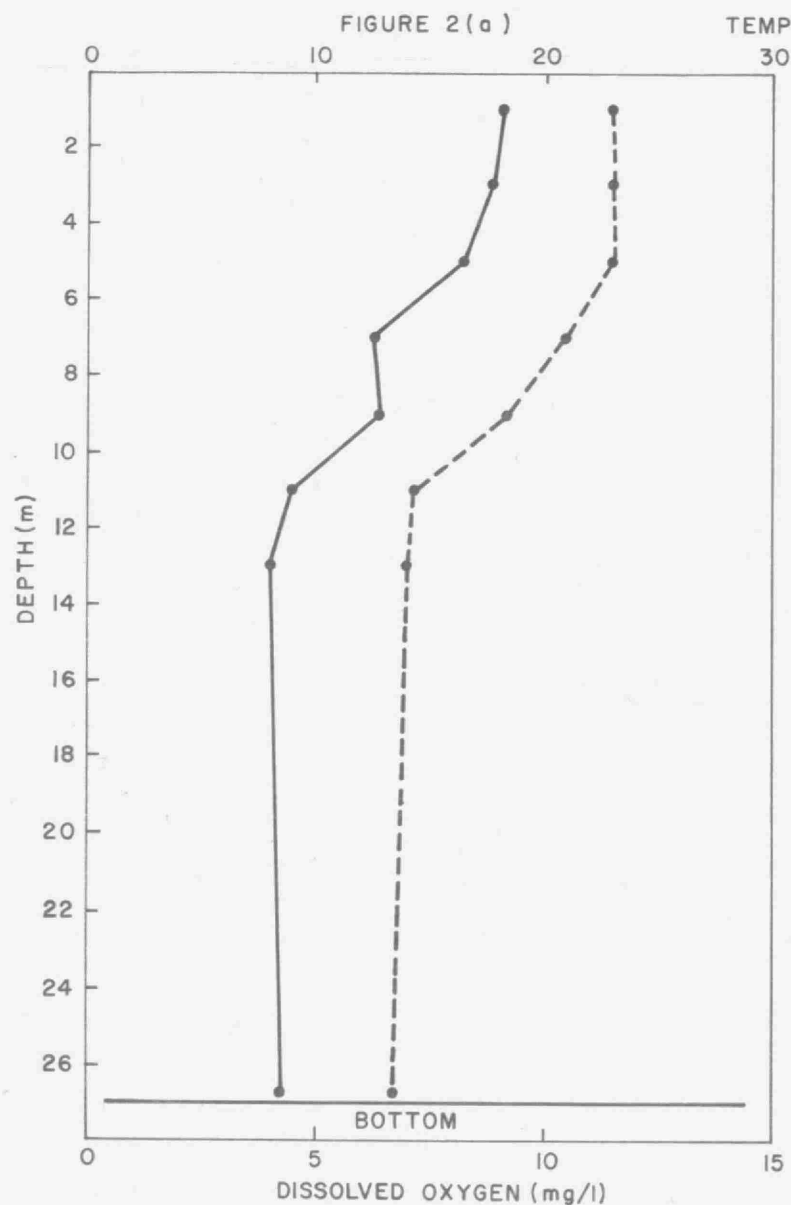


FIGURE 2: TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN OTTY LAKE, STATION 38 JUNE 12/71 (a) AND STATION 37 AUGUST 13/71 (b). THE SHADED AREA APPROXIMATES THE POSITION OF THE THERMOCLINE.

FIGURE 3 OCTOBER 25/71

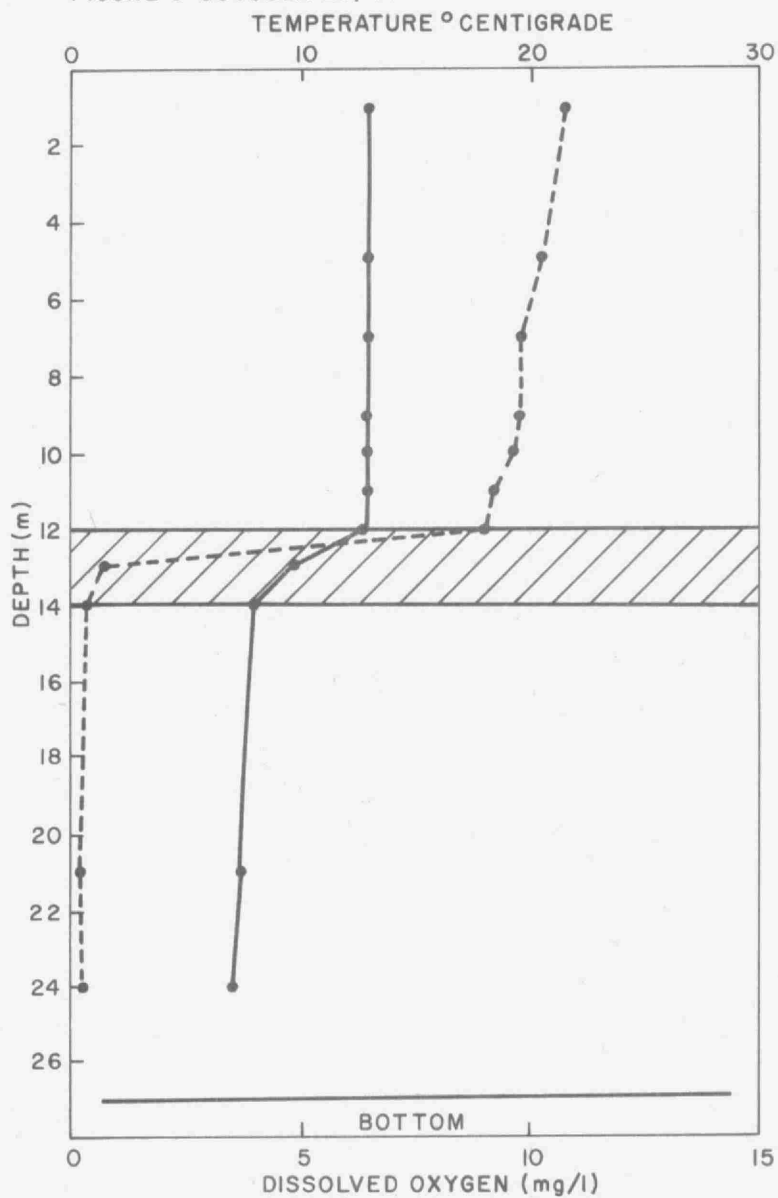


FIGURE 3: TEMPERATURE AND DISSOLVED OXYGEN PROFILE IN OTTY LAKE FOR STATION 38. THE SHADED AREA APPROXIMATES THE POSITION OF THE THERMOCLINE.

—•— TEMPERATURE
 - - -•- DISSOLVED OXYGEN

Carbon dioxide concentrations in the surface waters were low throughout the year (i.e. ranging from 0.0 to 2.3 mg/l) while bottom values were considerably higher (i.e. ranging from 3.2 to 36.4 mg/l). A definite increase in the deep-water carbon dioxide level was apparent between the August and October surveys. Specifically, at Station 37 on August 14 at 1 and 9m, values were 0.0 and 16.0 mg/l respectively while corresponding values on October 26 were 1.7 and 36.4 mg/l respectively. The high deep-water carbon dioxide concentrations as well as the above mentioned depressed pH values are related to conditions of organic decomposition.

Alkalinity concentrations were generally similar or higher in the bottom waters than in the surface strata. For example, on August 13 at Station 37, values at 1 and 19m were 109 and 115 mg/l respectively. The higher total alkalinity values in the bottom relative to surface concentrations indicate that release of bicarbonate from the sediments in conjunction with calcium, magnesium, iron, manganese and ammonia was occurring by bacterial and chemical action.

Hardness, Conductivity, Chloride and Iron

The hardness, conductivity and chloride data (Table 1) were consistent with each other indicating that no unusual mineral characteristics were present.

The hardness is such that cottagers might be attracted to using detergents containing phosphates for washing purposes. If these detergents are used by cottagers, every effort should be made to ensure that the waste disposal system does not allow any phosphates to gain access to the lake.

The iron concentrations were uniformly low at all stations.

Kjeldahl Nitrogen and Total Phosphorus

Surface water concentrations of Kjeldahl nitrogen and total phosphorus were generally low and would not be expected to support nuisance levels of algae.

There were higher concentrations of both nitrogen and phosphorus in the bottom waters at Station 37 on October 26 and at Station 38 on August 8 and October 26. These high concentrations are likely due to recycling from the sediments under the nearly anoxic conditions which prevailed during the same period. It is possible that when the lake cools to a uniform temperature the nitrogen and phosphorus could be mixed into the surface waters and augment algal growth.

Chlorophyll a

Algal densities in Otty Lake, as reflected by chlorophyll a concentrations were generally low, although a slight increase in populations between the June and October surveys was evident (Table 2). The algal levels encountered would not be expected to cause a reduction in water-oriented recreational activities such as swimming and water skiing or diminish the aesthetic quality of the lake.

As indicated above, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc.

Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lakes of Precambrian origin. Figure 4 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes located primarily in Southern Ontario. Points for eutrophic lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration **lies along** the horizontal limb. Data for mesotrophic lakes would be dispersed about the middle section of the curve. The slightly enriched nature of Otty Lake is indicated by its close proximity to values computed for Lake Ontario and the Eastern Basin of Lake Erie - two oligotrophic to mesotrophic bodies of water. Significantly, Otty Lake is well-removed from the Bay of Quinte, the Western Basin of Lake Erie, Riley Lake and Gravenhurst Bay - four highly enriched lakes.

Bacteriology

Otty Lake was well within the OWRC criteria for total body contact recreational use (OWRC 1970) and was homogeneous for TC, FC and FS during all three surveys (Figure 5) The overall geometric means for the three surveys are as follows:

<u>Parameter</u>	<u>SURVEY</u>		
	<u>June 11-15</u>	<u>August 12-16</u>	<u>October 23-26</u>
TC	10/100 ml.	3/100 ml.	13/100 ml.
FC	2/100 ml.	1/100 ml.	1/100 ml.
FS	2/100 ml.	2/100 ml.	1/100 ml.

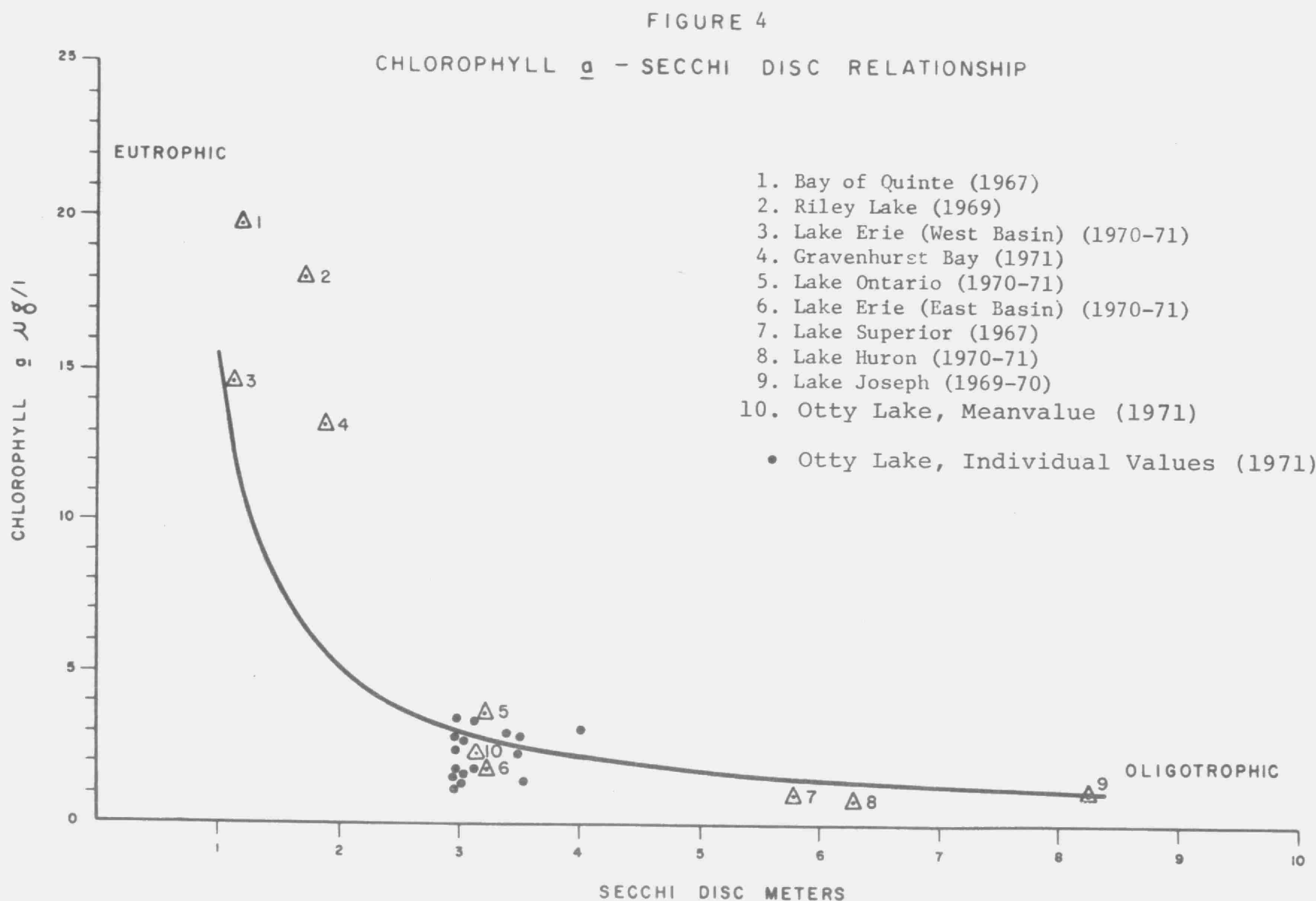
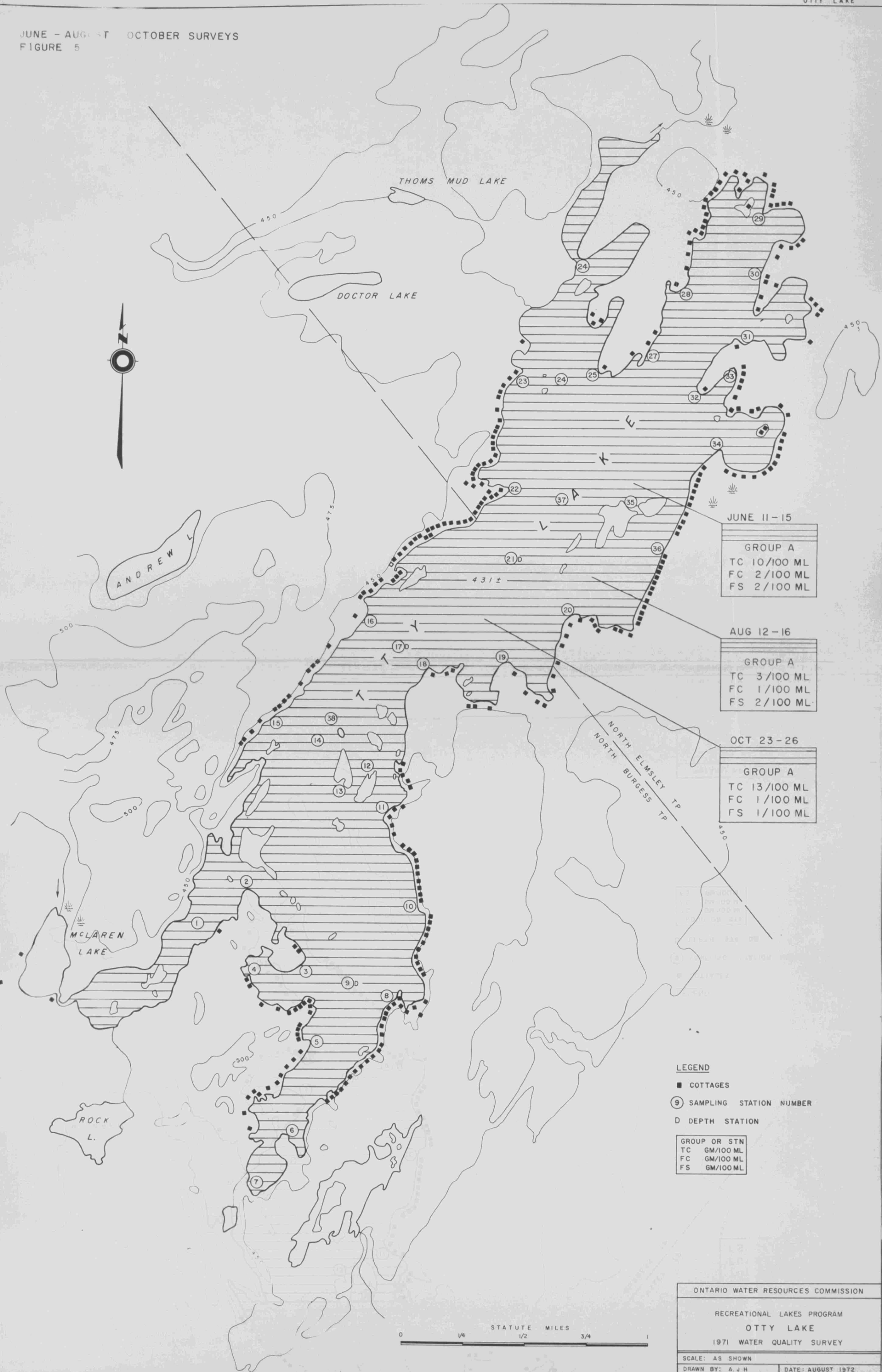


Figure 4: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual and overall mean values of chlorophyll a - Secchi disc for Otty Lake. The values for the Great Lakes were added for comparative purposes.

JUNE - AUGUST OCTOBER SURVEYS
FIGURE 5



JUNE 11-15

GROUP A	
TC	10/100 ML
FC	2/100 ML
FS	2/100 ML

AUG 12-16

GROUP A	
TC	3/100 ML
FC	1/100 ML
FS	2/100 ML

OCT 23-26

GROUP A	
TC	13/100 ML
FC	1/100 ML
FS	1/100 ML

LEGEND

■	COTTAGES
9	SAMPLING STATION NUMBER
D	DEPTH STATION
GROUP OR STN	
TC	GM/100 ML
FC	GM/100 ML
FS	GM/100 ML

During the June survey, the lake had low geometric mean levels of 10 TC/100 ml, 2 FC/100 ml, and 2 FS/100 ml.

Bacterial levels were very low during the August survey, although an increase in FS concentrations were noted at Stations 6, 8 and 21 after a light rainfall on August 11. A similar increase was observed at Station 2 with a count of 36 FS/100 ml and Station 39 with 70 FS/100 ml following a 0.2 inch rain on August 14.

The October survey, with overall geometric means of 13 TC/100 ml, 1 FC/100 ml, and FS/100 ml was well-within the recreational use criteria.

Although Otty Lake had excellent bacteriological water quality for recreational use no surface water is considered potable without prior treatment including disinfection.

TABLE 1

Iron, Hardness (Hard), Total Phosphorus (P), Total Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Otty Lake, 1971.
Results are expressed in mg/l except conductivity which is umhos/cm³.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
1	1m	11/6	0.05	122	0.014	0.42	3	-
1	1m	15/8	0.05	120	0.016	0.40	3	229
24	1m	11/6	0.05	124	0.010	0.42	3	-
24	1m	26/10	0.05	122	0.020	0.48	3	235
37	6m comp	13/6	0.05	124	0.018	0.50	4	235
37	5.6m comp	15/8	0.0	122	0.016	0.49	3	231
37	19m	15/8	-	-	0.020	0.48	-	-
37	6.4m comp	26/10	0.05	122	0.012	0.46	3	232
37	20m	26/10	0.10	-	0.070	0.85	-	-
38	6.4m comp	13/6	0.05	124	0.014	0.48	3	234
38	5.6m comp	15/8	0.0	122	0.012	0.43	3	236
38	23m	15/8	-	-	0.054	0.52	-	-
38	8m comp	26/10	0.05	122	0.014	0.43	3	232
38	20m	26/10	0.05	-	0.050	0.65	-	-

"comp" means a composite sample taken through the depth indicated

means "less than"

TABLE 2

Chlorophyll a and Secchi disc values for Otty Lake, Stations 37 and 38 during 1971.

DATE	Station 37		Station 38	
	Chlor a	S.D.	Chlor a	S.D.
June 11	1.4 ug/l	3.5 m	1.6 ug/l	3.0 m
June 12	1.0	2.0	1.2	3.0
June 13	1.6	3.0	1.9	3.2
June 14	2.9	3.0	2.5	3.0
August 12	1.5	3.0	1.8	3.0
October 25	2.8	3.5	2.3	3.5
October 26	3.5	3.2	3.1	4.0
October 27	3.0	3.4	2.9	3.5
Mean	2.2	3.1	2.2	3.3

Overall mean

Chlorophyll a 2.2 μ g/l

Secchi disc 3.2 m

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where
$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$		

N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 3

OTTY LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS
 PARAMETER - TOTAL COLIFORM/100 ml (TC)

SURVEY	JUNE 11-15	AUGUST 12-16	October 23-26
GROUP TOTAL LAKE	TOTAL LAKE	TOTAL LAKE	TOTAL LAKE
F	1.223	0.912	0.719
df	40,162	42,170	42,133
F 5%	1.484	1.473	1.490
	-NSD	-NSD	-NSD
log G.M.	0.9855	0.5187	1.044
S.E.	0.0468	0.0387	0.0414
N	203	213	176
G.M.	9.672	3.301	11

TABLE 4

OTTY LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS
PARAMETER - FECAL COLIFORM/100 ml (FC)

SURVEY	JUNE 11-15	AUGUST 12-16	October 23-26
GROUP	TOTAL LAKE	TOTAL LAKE	TOTAL LAKE
F	0.543	0.765	0.721
df	40,161	42,170	38,121
F 5%	1.485	1.473	1.515
	-NSD	-NSD	-NSD
log G.M.	0.2239	0.0427	0.0056
S.E.	0.0325	0.0132	0.0034
N	202	213	160
G.M.	2	0.1	0

TABLE 5

OTTY LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS
PARAMETER - FECAL STREPTOCOCCUS/100 ml (FS)

SURVEY	JUNE 11-15	AUGUST 12-16	October 23-26
GROUP	TOTAL LAKE	TOTAL LAKE	TOTAL LAKE
F	1.379	0.823	0.860
df	40,162	42,170	38,121
F 5%	1.484	1.473	1.515
	-NSD	-NSD	-NSD
log G.M.	0.1900	0.2286	0.0637
S.E.	0.0233	0.0269	0.0152
N	203	213	160
G.M.	0.1	0.1	0.1

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC

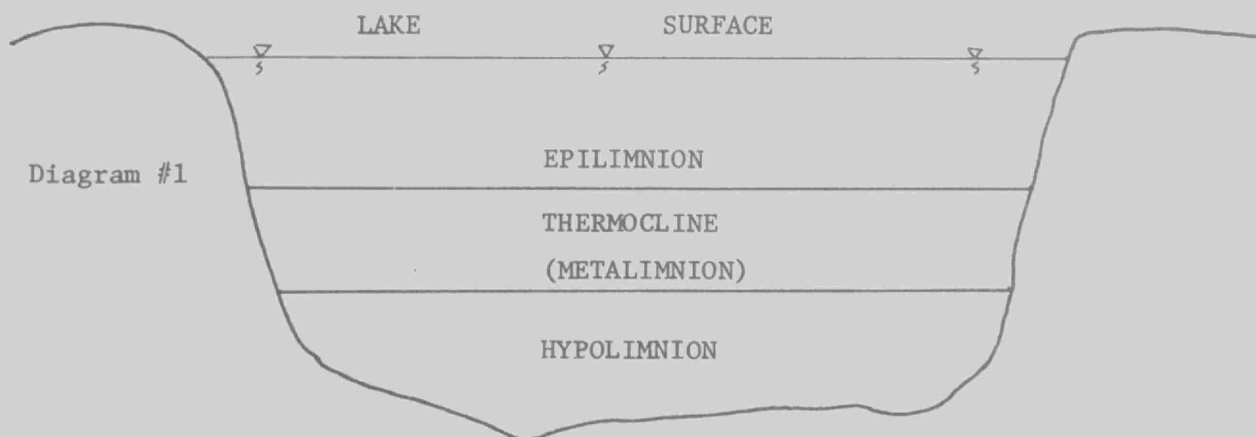
:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION

:During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion)

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.



TOTAL COLIFORMS (TC)

:Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS

:Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria

Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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